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Manual of Instructions

MODEL 505
Gaussmeter

MASTER

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RFL Industries, Inc.
Boonton, New Jersey, U. S. A.

Book No. MA-28400

MASTER

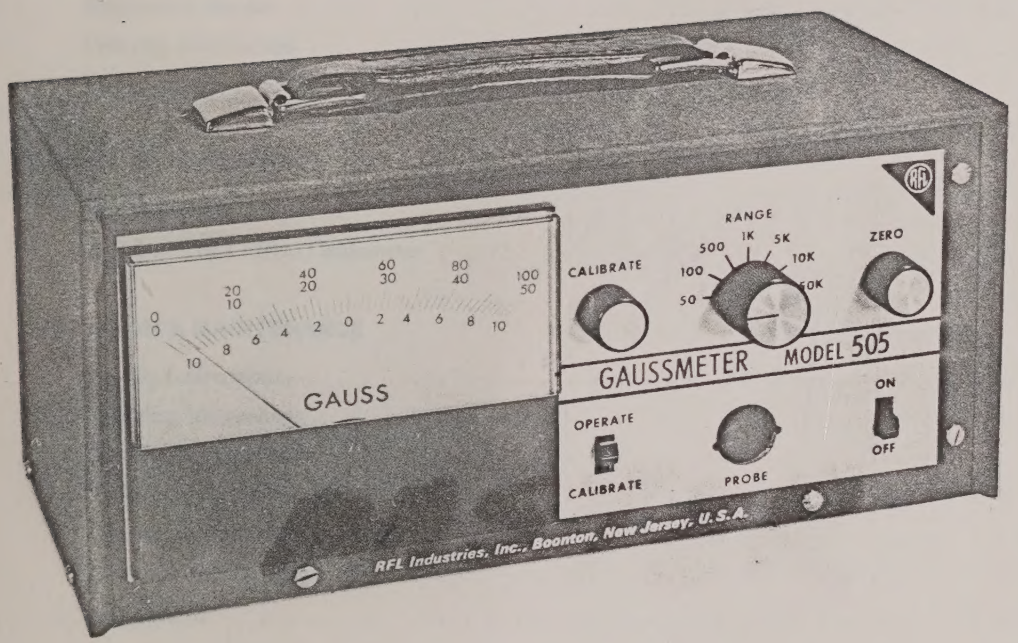
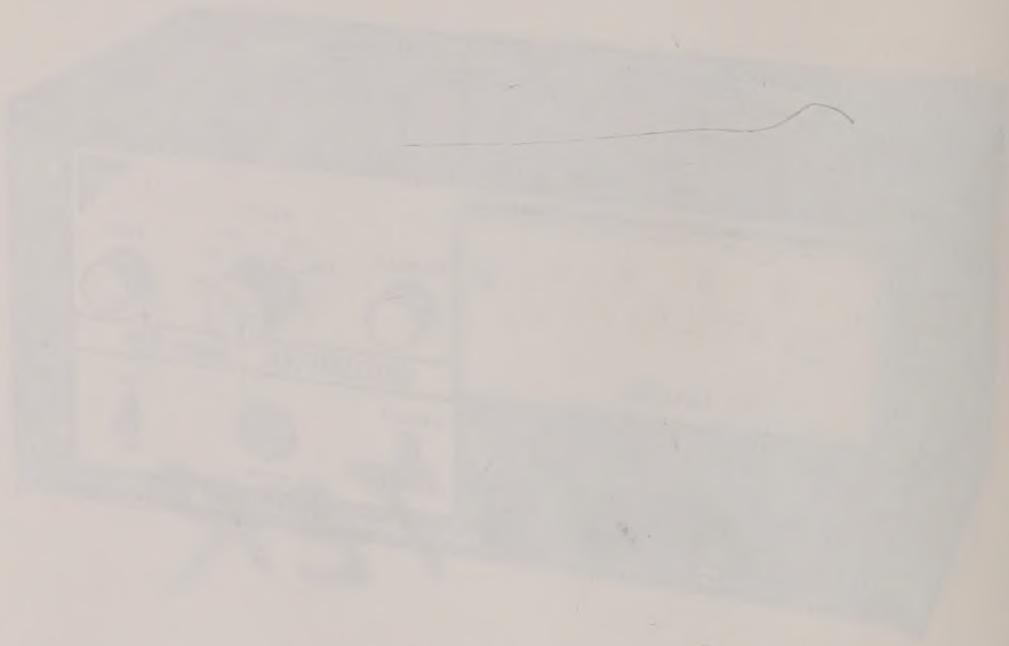


Figure 1. Front View of Model 505 Gaussmeter.



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GENERAL

SCOPE OF MANUAL

This manual provides complete operating and maintenance instructions for the Model 505 Gaussmeter. Also included are various applications and measurement techniques.

MECHANICAL INSPECTION

The Model 505 Gaussmeter is carefully packed to insure against damage from normally rough treatment in transit. Any damage, concealed or otherwise should be reported immediately to the carrier with a copy to RFL Industries, Inc. Please retain cartons and packing material until an investigation of the damages by the carrier or its insurance representative is completed.

ENGINEERING SERVICE

RFL Industries, Inc. maintains a Magnetic Measuring Applications Engineering Section to provide measuring techniques for individual customer requirements. All inquiries, special or routine, are welcomed. Recommendations are made on a composite basis of economy and reliability.

ORDERING INFORMATION

The basic unit consists of the Model 505 Gaussmeter including a battery supply. Two standard probes are available, a Transverse (HB-28430) and Axial (HB-28425). See Figure 2.

DESCRIPTION

The Model 505 Gaussmeter is a compact, highly versatile instrument designed for the measurement of magnetic flux density. The Model 505 is capable of measuring magnetic field strengths ranging from 5 gauss to 50,000 gausses in seven full-scale ranges of 0 to 50; 100; 500; 1000; 5000; 10,000 and 50,000 gausses. The circuit is designed to allow the Model 505 to be used as a zero left or zero center instrument to facilitate measurements where polarity is of any consequence. In the zero center mode, the ranges are: 25-0-25; 50-0-50; 250-0-250; 500-0-500; 2500-0-2500; 5000-0-5000 and 25,000-0-25,000 gausses. Accuracy of the instrument is ±3% of full scale range value.

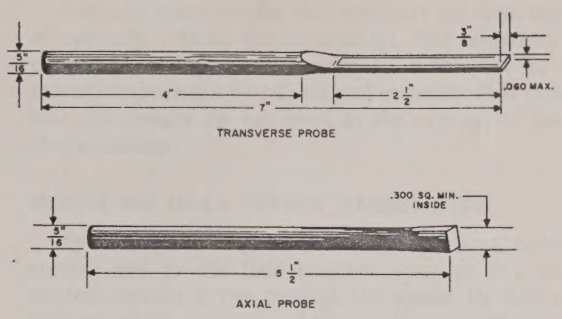


Figure 2. RFL Transverse and Axial Probes.

The Model 505 incorporates a self-check calibration feature which precludes the necessity of using reference magnets for all but the most precise measurements.

The Model 505 incorporates a precision 4½" taut-band meter. An auxiliary output enables recorder or oscilloscope connection. With oscilloscope presentation, AC and pulsed magnetic fields can be observed and measured.

Both transverse and axial probes are available; each probe being ruggedized to a high degree to enable virtually damage-free operation.

The Model 505 may be operated from either a battery supply or AC (115-230, 50/60 Hz) line.

SPECIFICATIONS

Accuracy: ±3% of full-scale range value

Ranges: Two selectable modes—Seven positions

Zero left (0 to 50; 100; 500; 1000; 5000; 10,000; 50,000 gausses)

Zero center (25-0-25; 50-0-50; 250-0-250; 500-0-500; 2500-0-2500; 5000-0-5000; 25,000-0-25,000 gausses)

Calibration: Self-check calibration on any range

Frequency Range of Measurement: Permanent magnet, DC and AC fields to 20 kHz

Resolution: 0.2 of scale division

Accessory Output: 100 millivolts full-scale range

Power Supply: Battery operation, three standard 1.5 volt batteries, D size. Four standard 1.5 volt penlite cells, AA size. (AC supply is available for 115-230V, 50/60 Hz line)

Dimensions: 5¼" high x 11½" wide x 5½" deep (13.3 cm x 28.2 cm x 13.9 cm)

Weight: 5.5 pounds (2.5 kilograms)

THEORY OF OPERATION

THE HALL EFFECT

When electrons move in a conductor perpendicular to a magnetic field, they are deflected toward one side of the conductor (left or right depending on the direction of the magnetic field) in a direction normal to the direction of both the initial electron flow and the magnetic field. The force deflecting the electrons is directly proportional to the current and the magnetic field intensity. This deflection process continues until sufficient charge has accumulated at the sides of the conductor to establish a transverse electric field which opposes further deflection of charge carriers. The transverse potential difference thus created is called the Hall voltage; the phenomena causing it, the Hall effect.

The magnitude of this potential in volts is given by the equation:

$$E = \frac{RIH}{t}$$

where I is the current in amperes, H is the magnetic field strength in gauss, t is the thickness of the sample in centimeters and R is the Hall coefficient in volt-cm/ampere gauss.

Under the conditions shown in Figure 3, the terminal B will be negative with respect to terminal A for metals and semiconductors in which the current is carried by electrons. Reversing the field reverses the output polarity. The width of the strip is not a factor of the output as long as it is large compared to the thickness. For thin strips the output is unaffected by the frequency of the field in the audio range. The Hall voltage is maximum when the plane of the element is perpendicular to the magnetic field.

Practical materials for Hall elements are films and slabs of specially refined semiconductors. The sensitivity, temperature stability and linearity to fields can be varied through wide ranges by selection of materials. One characteristic can usually be improved at the expense of the other characteristics.

MODEL 505 HALL EFFECT GAUSSMETER

The voltage for a given probe is proportional to its drive current and to the field incident upon it. If a constant control current is run through the probe, its Hall voltage will be solely proportional to the magnetic flux incident on the Hall element. By selecting the constant current, various full-scale ranges may be accommodated.

In the Model 505 Gaussmeter a constant current is provided by Q1 and its associated biasing. This constant current is fed to the probe via switch S2 and resistors R9 - R15. The attenuator is designed to present a constant impedance to Q1 and to shunt to ground a known portion of the constant current. The portion of current not shunted to ground is fed to the probe. The normal output of the probe is about 1.5 mV for any given full scale indication. This output is amplified by IC1 to supply current drive for meter M1. The input of IC1 is also connected to a variable reference voltage which controls the zero offset of the amplifier and allows the indicating meter to be zeroed using a wide range of probes. Gain of the integrated circuit is set by R28 and R31. Internal self-calibration is accomplished in the following manner: A known portion of the constant current produced by Q1 is fed through a calibration resistor R2 to R3. Calibration resistor R2 is selected at the factory using RFL magnetic reference standards traceable to the National Bureau of Standards. In the calibrate mode, the voltage across R3 is fed to the IC amplifier to give an indication as the current source is varied.

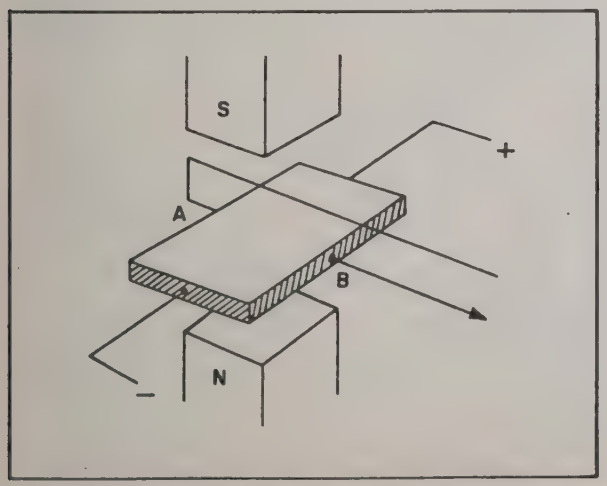


Figure 3. Schematic Circuit Arrangement for the Measurement of the Hall Coefficient.

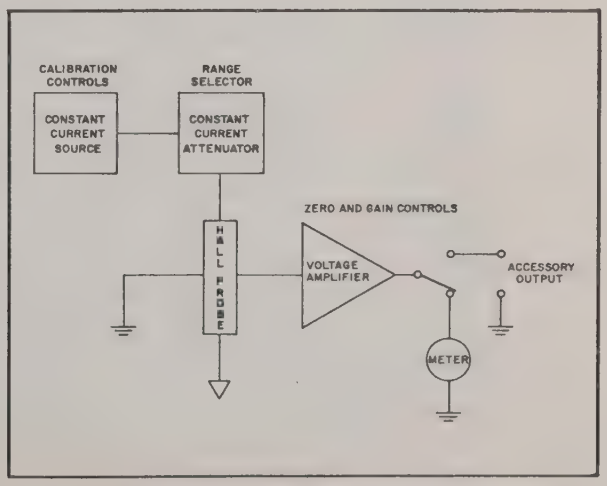


Figure 4. Block Diagram of the Model 505 Gaussmeter.

OPERATION AND MAINTENANCE

SET-UP INSTRUCTIONS

1) Check to see that your Model 505 Gaussmeter was shipped as ordered. See that the proper probe and power unit are present.

2) Install batteries as marked in Figure 5 and connect the battery supply to the instrument. The supply/rear panel can then be attached to the Model 505. If AC power is used, connect the AC power supply to the instrument, then attach the supply/rear panel.

3) Plug the desired probe through the front panel to recessed connector.

4) The Model 505 Gaussmeter is ready for use. Refer to the operating instructions for proper use of the instrument.

OPERATING INSTRUCTIONS

A. Set Range switch to an appropriate range. (The 1K range will provide the highest accuracy.)

B. Set Operate/Calibrate switch to the Operate position and zero the gaussmeter using the zero control. On the 50 gauss range the earth's magnetic field can cause an offset error of up to 2%. The probe should be rotated until a minimum is reached to reduce any error.

C. Set Operate/Calibrate switch to Calibrate position and adjust calibrate control until meter reads number stamped on probe.

D. Return the Operate/Calibrate switch to Operate and make the desired measurement.

E. Check the settings of the Zero and Calibrate controls periodically to insure accurate readings. If insufficient range is noted on either the zero or calibrate control, refer to the adjustment procedure section of this manual for adjustments.

When calibrating the gaussmeter used with battery supply and insufficient range is noted on the calibrate control, the batteries should be replaced. In normal operation, 200 operating hours can be expected of the batteries. In an emergency, the gain control may be adjusted to extend battery life several hours. Refer to Adjustment Procedure.

ZERO-CENTER OPERATION

This feature is useful when accurate measurement of magnetic field polarity is important. The red side of the flat probe, or the front end of the axial probe, when pointed toward a magnetic pole which attracts the north-seeking pole of a compass will cause a positive meter deflection. This means that when the red, or front of a probe is pointed geographically north, a positive deflection will result.

Zero and calibrate the instrument in the normal manner, with the zero at the left end of the meter scale. For zero-center operation, do not touch the calibrate control and rotate the zero control until the meter indicates zero on the zero-center scale. The left or right full scale indications will then be half of the value set on the range switch. Note that if an attempt to calibrate is made, the meter will indicate offscale. To recheck calibration, the instrument must be returned to zero-left operation.

OSCILLOSCOPE OUTPUT TERMINALS

Disconnect the jumper lug from the terminal strip. The output of the Model 505 is now available at the two indicated lugs; #1 being the gaussmeter common, #3 being

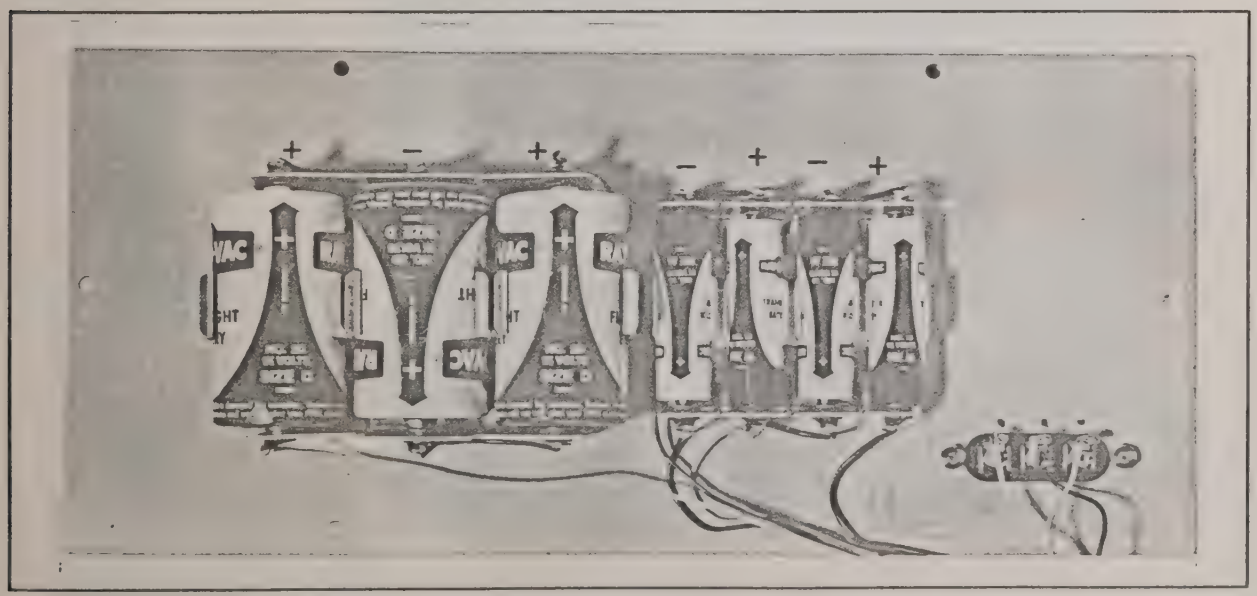


Figure 5. Battery Supply/Rear Panel Showing Correct Polarity.

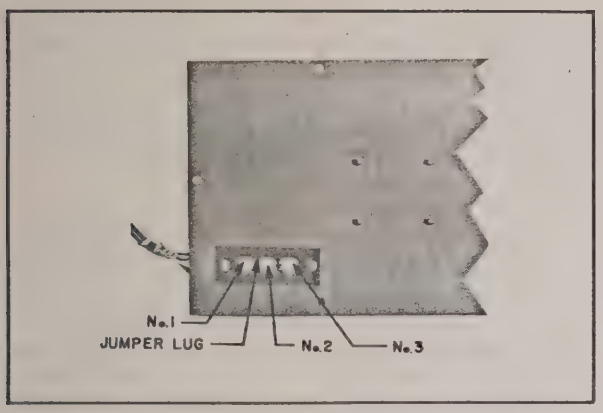


Figure 6. Output Connections (Rear Panel).

the output. (See Figure 6.) The oscilloscope should be calibrated in the following manner.

1) Switch the oscilloscope to DC operation.

2) Set Model 505 Operate/Calibrate switch to Calibrate position.

3) Observe deflection of the oscilloscope beam and set its sensitivity control and the 505 calibrate control to obtain deflection equal to the calibrate number on the probe.

An RMS voltmeter may be connected across terminals 1-3 to be used in conjunction with or in lieu of the oscilloscope. The AC voltmeter will give an indication of the RMS, or effective value of the waveform under measurement.

ADJUSTMENT PROCEDURE

Only two adjustments are required for proper operation of the Model 505 Gaussmeter. (See Figure 7.)

A. COARSE ZERO

1. Insert probe to be used with instrument.
2. Set front panel Operate/Calibrate control to Operate.
3. Turn front panel Zero control to far clockwise position.
4. Adjust coarse Zero control so that the indicating meter reads approximately full scale.

B. GAIN

1. Insert probe to be used with the instrument.
2. Zero the gaussmeter as per "Operating Instructions."
3. Set the Operate/Calibrate control to Calibrate.
4. Set Calibrate control to approximately a two o'clock position.
5. Adjust Gain control so that the indicating meter reads approximately the CAL number on the probe.
6. The Model 505 Gaussmeter is now ready for operation.

TROUBLE-SHOOTING PROCEDURE

The most common cause for trouble with the Model 505 Gaussmeter will be weak batteries. The symptom to look for is the inability to calibrate the instrument. First

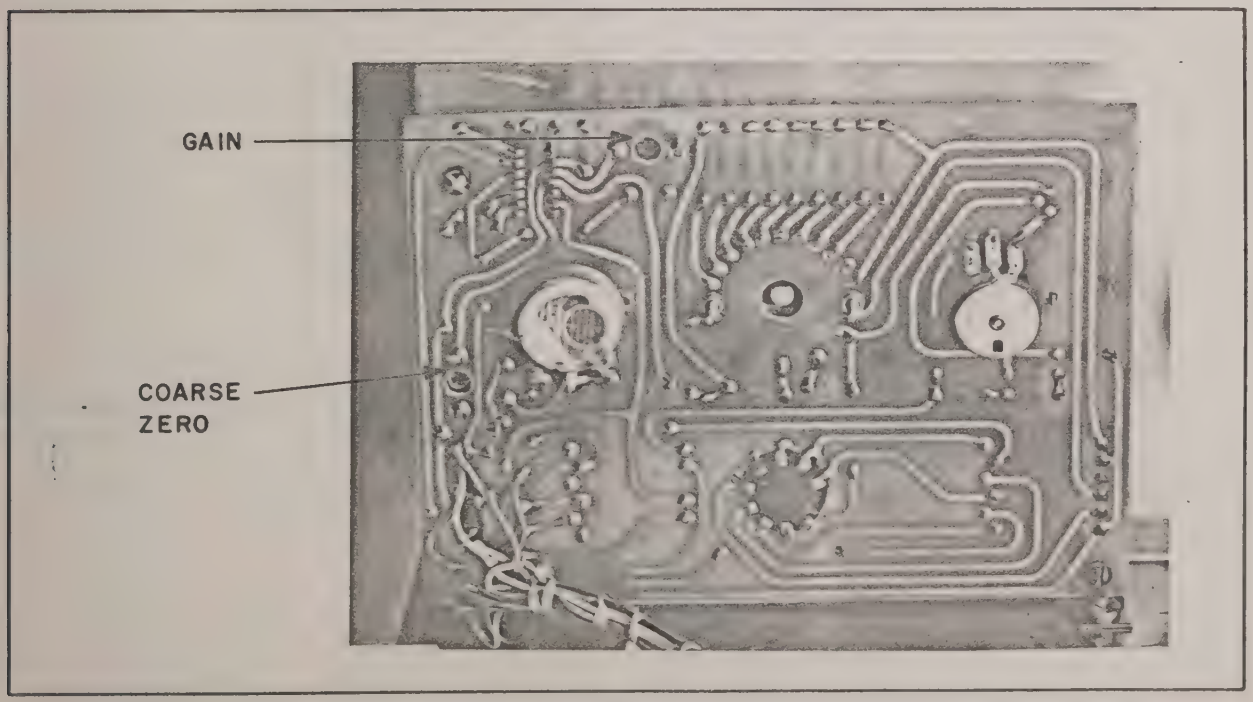


Figure 7. Inside View Showing Coarse Zero and Gain Controls.

replace the three large probe bias supply batteries. The four small instrument supply batteries will have a life several times that of the probe bias supply batteries. If replacing batteries does not improve gaussmeter operation, the Gain control is improperly adjusted. Refer to the Adjustments section of this manual for setting the Gain control properly.

APPLICATIONS

The Model 505 Gaussmeter is designed for use in both qualitative production analysis and basic engineering research of permanent or electromagnet structures. The instrument may be used with easily fabricated fixtures to enable rapid sorting or inspection of permanent magnet components in a quality assurance program to insure acceptability of the final assembled product. The use of the Model 505 in its zero center mode enables it to be operated as a go-no-go gage by unskilled personnel who are unfamiliar with magnetic polarity and where inspection time must be at a minimum. The gaussmeter can be used for inspecting all types of permanent magnet shapes: bar, plug, wafer, C shape, U shape, disc, cylindrical and multipole.

Production testing of completed magnetic assemblies may be readily accomplished using the Model 505. Both axial and transverse fields in traveling wave tube assemblies may be accurately measured. The gap field as well as extraneous leakage fields in magnetron structures can be measured. Other applications for the gaussmeter are: the measurement of flux density in accelerometer working gaps; relative and absolute measurement of magnetic field strength in holding magnet assemblies; determination of residual magnetism in relay armature gaps; magnetic quality of generator and alternator assemblies; and in virtually any assembly where a static or pulsating magnetic field is generated by a permanent or electromagnetic component.

The Model 505 may also be used to measure and analyze alternating magnetic fields (up to 20 kHz) and pulsed fields having time duration in the microsecond region, using an oscilloscope in conjunction with the Model 505 Gaussmeter. This technique allows the operator to see the amplitude and waveform of alternating fields. In this manner, unwanted fields are detected and analyzed providing previously unobtainable information for the design and quality control engineer. Transformer flux leakage, the amplitude of electromagnetic pulses and many other transient magnetic phenomena, may be readily observed using the Model 505.

TROUBLESHOOTING CHART

SYMPTOM	CAUSE	REMEDY
Unable to calibrate	Improper adjustments or weak batteries	Check adjustments section for proper set up procedure. If battery replacement is required, check first the three large probe bias supply batteries.
No output or erratic output	Cracked Hall element	Replace probe with a known working probe. Return damaged probe to RFL for repair or replacement.
No output	Current source defective	There should be 1 volt ±30% across R21. If not, check Q1 and CR1, 2 and 3 for failure.
Unable to adjust unit so pointer remains on scale	Improper adjustment procedure or defective IC OP. Amp.	Check adjustment section for proper set up procedure. Check voltage on Pin 12. If this voltage exceeds ±1V, IC 101 should be replaced.

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
	MODEL 505 GAUSSMETER	
C1, 2	CAPACITOR, silver mica: 56 pF, ±5%, 500V	HA-16517
CR1-5	DIODE, silicon: SD 2	HA-17995
IC1	INTEGRATED CIRCUIT	HA-27425
Q1	TRANSISTOR: 2N2102	HA-22678
R9, 20	RESISTOR, carbon film: 6 ohms ±1% ¼ W	H-1510-987
R10	RESISTOR, carbon film: 54 ohms ±1%, ¼ W	H-1510-993
R11	RESISTOR, carbon film: 114 ohms ±1%, ¼ W	H-1510-994
R12	RESISTOR, carbon film: 594 ohms ±1%, ¼ W	H-1510-995
R13	RESISTOR, carbon film: 1194 ohms ±1%, ¼ W	H-1510-996
R14	RESISTOR, carbon film: 5994 ohms ±1%, ¼ W	H-1510-997
R15	RESISTOR, carbon film: 12 ohms ±1%, ¼ W	H-1510-992
R16	RESISTOR, carbon film: 6.67 ohms +1%, ¼ W	H-1510-991
R17	RESISTOR, carbon film: 6.32 ohms ±1%, ¼ W	H-1510-990
R18	RESISTOR, carbon film: 6.06 ohms ±1%, ¼ W	H-1510-989
R19	RESISTOR, carbon film: 6.03 ohms ±1%, ¼ W	H-1510-988
R21	RESISTOR, fixed comp.: 10 ohm ±5%, ½ W	H-1009-238
R22	RESISTOR, variable: WW, mod. WP/A28406	HA-28407
R23	RESISTOR, fixed comp.: 100 ohm ±5%, ¼ W	H-1009-758
R24, 26	RESISTOR, fixed comp.: 16K ±5%, ¼ W	H-1009-847
R25	RESISTOR, variable, comp.: 1K, ¼ W	HA-22089
R27	RESISTOR, variable, comp.: mod. WP/A28408	HA-28409
R28	RESISTOR, variable, comp.: 50K, ¼ W	HA-28410
R29	RESISTOR, fixed comp.: 10K ±5%, ¼ W	H-1009-742
R30	RESISTOR, fixed comp.: 470 ohms ±5%, ¼ W	H-1009-751
R31	RESISTOR, fixed comp.: 200 ohms ±5%, ¼ W	H-1009-785
R32, 33, 34	RESISTOR, fixed comp.: 1K ±5%, ¼ W	H-1009-612
R35, 36	RESISTOR, fixed comp.: 1.5K ±5%, ¼ W	H-1009-822
R37	RESISTOR, fixed comp.: 20K ±5%, ¼ W	H-1009-773
S1, 2	SWITCH, slide: 4PDT	HA-28411

Table of Replaceable Parts

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
	MODEL 505 AC POWER SUPPLY	
C101, 102	CAPACITOR, electrolytic: 100 μF, -10% +75%, 2V	H-1007-857
CR101	DIODE: 1A, 25V, W110	HA-28434
CR102, 103	DIODE, Zener: 62V, 10%, 1 W	HA-26468
Q101	TRANSISTOR, power: silicon 2N5293	HA-28433
R101	RESISTOR, fixed comp.: 68 ohms ±10%, 1 W	H-1009-690
R102	RESISTOR, fixed comp.: 75 ohms +10%, 1 W	H-1009-980
R103	RESISTOR, fixed comp.: 56 ohms +10%, 1 W	H-1009-936
R104, 105	RESISTOR, fixed comp.: 100 ohms ±5%, ¼ W	H-1009-758
T101	TRANSISTOR, power	HB-28439

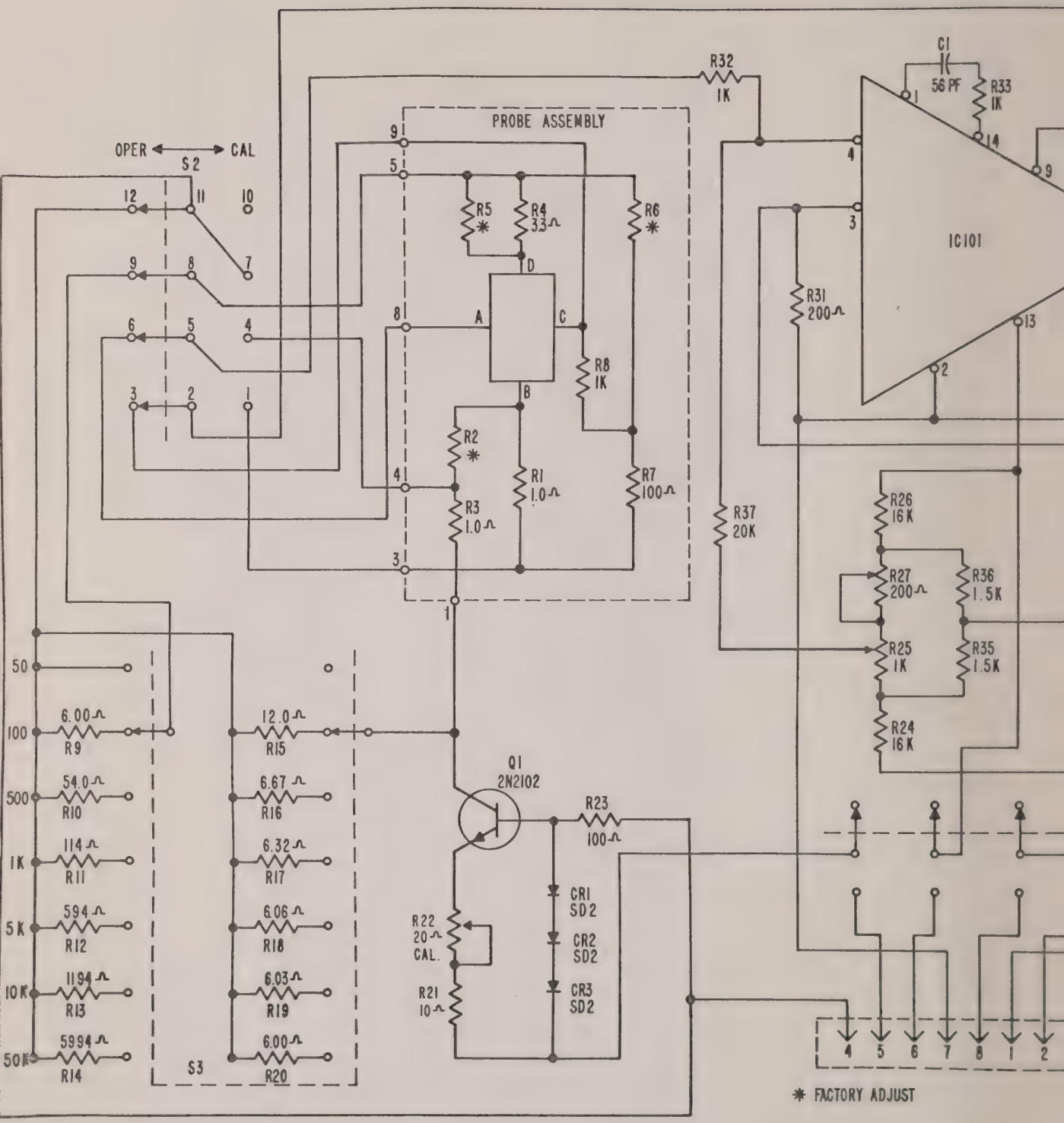
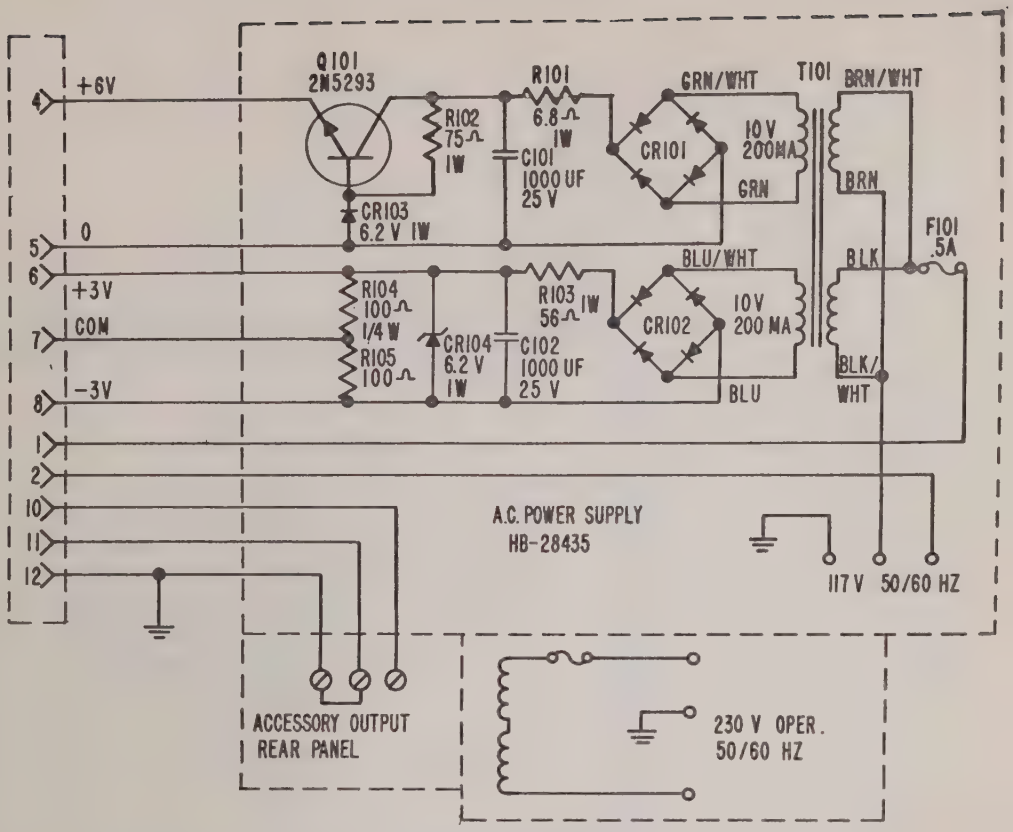
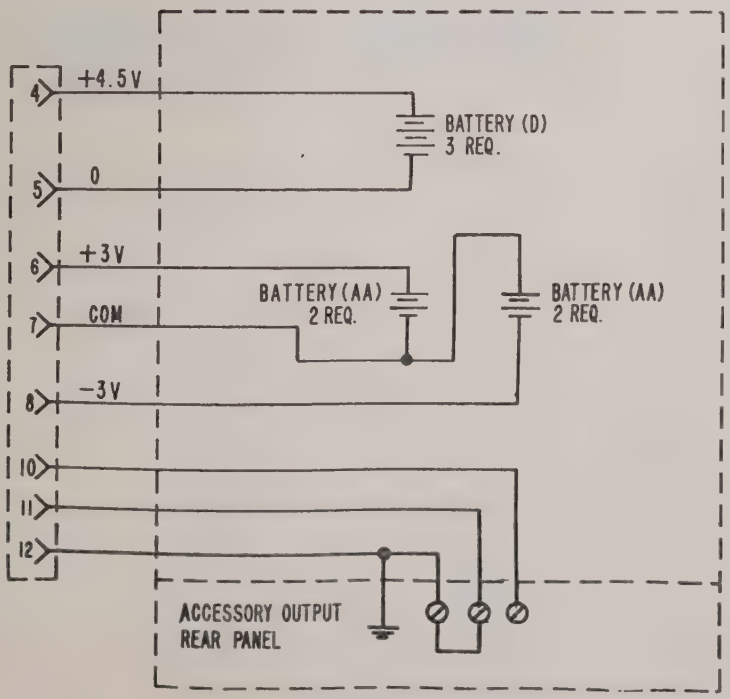


Figure 8. Schematic Diagram of Model 505 Gaussmeter.

R29
10K
R28
50K
R30
470Ω
M1
CR4
CR5


+6V
0
+3V
COM
-3V
Q101
2N5293
R101
6.8Ω
1W
R102
75Ω
1W
C101
1000 UF
25 V
CR103
6.2 V 1W
CR101
10 V
200MA
GRN/WHT
GRN
T101
BRN/WHT
BRN
BLK
F101
.5A
BLU/WHT
R104
100Ω
1/4 W
R105
100Ω
CR104
6.2 V
1W
R103
56Ω 1W
C102
1000 UF
25 V
CR102
10 V
200 MA
BLU
BLK/
WHT
A.C. POWER SUPPLY
HB-28435
117 V 50/60 HZ
ACCESSORY OUTPUT
REAR PANEL
230 V OPER.
50/60 HZ


+4.5V
0
+3V
COM
-3V
BATTERY (D)
3 REQ.
BATTERY (AA)
2 REQ.
BATTERY (AA)
2 REQ.
ACCESSORY OUTPUT
REAR PANEL

Warranty

The Model 505 Gaussmeter carries a warranty of twelve months from date of delivery for replacement of any part, except probes, which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f.o.b. Boonton, N. J.

RFL Industries, Inc.

Boonton, New Jersey, U. S. A.

GENERAL ELECTRIC

INSTRUCTIONS FOR USE OF RFL 505 GAUSSMETER:

1. Install probe.
2. Turn unit on.
3. Place operate/calibrate switch to calibrate.
4. Adjust calibrate knob until meter reads the number printed on the probe plug.
5. Place switch to operate.
6. Adjust for zero at left end of scale.
7. Repeat steps 3 through 6 until unit is adjusted to read zero with proper calibration adjustment.
8. Be sure to re-check the zero and calibrate frequently.

NOTE: This unit operates from battery power - If unit fails to function, remove rear cover and check to see if batteries are properly seated.

Larry J. Stock
Rental Specialist
(213) 674-7900